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# Education, Science Policy, Research and Action.

## A Review Paper

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This paper is a reflection on some of the issues raised in papers and commentary at the seminar on 'Education, Science Policy, Research and Action', held in IDRC, New Delhi, January 10-13, 1984. The views expressed are the author's and in no way commit either IDRC or the participants at the meeting.

> Yet a basic question remains unanswered: can these (learning) processes indeed generate enough forces to counteract the forces of social disintegration? Strangely enough, from among the individuals and institutions who have in one way or another helped FUNDAEC, its own originators are the most critical and the least optimistic in this respect. Although they have never wished to attack any specific social or political group, they cannot deny that the hundreds of millions of rural inhabitants of the world are oppressed by a world system consisting of the two strong contending powers and their many subsidiaries and variations. By simple inertia or by design, the fruits of the hard labour of these millions are sucked away and are channelled to finance the thousands of mechanisms, including reform and revolution, used for the maintenance of the world system, and its favourite occupation, the production of weapons of destruction. Can the inhabitants of Norte del Cauca truly hope for a higher level of material well-being under these conditions? A simple transfer of a sum of money from one bank to another or a political alliance at a moment of convenience generate irresistible forces that determine the prices of their products, how much land they can possess, what technology they can use, and which propanganda they should be subjected to. How can their fragile economy withstand these huge forces of disintegration? The people of Norte del Cauca have certainly proved with FUNDAEC that, once offered viable alternatives, they are willing to participate in the processes of change. But change at the village level is only half of the challenge of development. The so-called developed world, including the modern sector of the third world countries, also has to change; in the final analysis, a prosperous village in Norte del Cauca can only exist as an organic part of a totally new world order. 1

## Introduction

The above quotation from a description of science-based change ina backward region of Colombia points up several of the themes addressed at a meeting of science educators, sociologists of science, engineers, science activists, science analysts and science policy makers. There

1. Farzam Arbab, 'Engineers for rural well-being', paper delivered to a meeting on Education, Science policy research and action (hereafter ESPRA), New Delhi, January 10-13, 1984, pp. 12-13.

is, firstly, the concern with continuity and change at the micro-level, whether in individual schools, villages, farms or forests in developing countries. Second, the learning processes associated with these changes seem broadly related to the impact of the particular traditions of science and technology, be these popular science, or appropriate technology, indigenous science or new technology. But thirdly, and most crucially, there is a question mark hanging over the larger science and technology system at the global and national level. In contradictory positions it is argued that science must be brought to all, in school and outside, and particularly in the Third World to make man modern and productive and more competitive with the industrialised North. Equally, it is argued, as in the above quotation , that whatever the innovativeness or dedication of the individual scientist in the village or science classroom, the wider texts of science and technology in the nation state and international economy do not reveal characteristics of objectivity, progressiveness and universalism, but rather betray a set of codes intimately connected with large scale capital, intensive systems of knowledge production, whether for agricultural, health, military or industrial application.

Although the broad outlines of the debates about the role of science and technology in development have been available for some time, this particular meeting was concerned to examine in greater detail several illustrations of the general debate. First, it seemed useful to examine the interaction between the policy debate about science and technology on the one hand and the rich variety of research and action on promoting science and technology through formal and nonformal learning on the other. Second, the disputes about the beneficial and/or baneful impact of science and technology might profitably be set against the extraordinary diversity of science-based intervention by committed individuals and groups in the rural areas of the Third World. Thirdly, both these activities, of science-in-education, and popular-science-for-villages, could exemplify or challenge interpretations of developing country science as broadly dependent on the initiatives, research, and priorities of the more developed, industrialised world. In the elaboration of these very local descriptions of science in action, it might be possible to judge whether there were indications that science was playing a liberatory role in rural community development, and in the encouragement of individual achievement, or whether, by contrast, the very process of applying science to the varied situations of rural and urban poverty was throwing up the need for new paradigms, alternative ways of thinking about the interrelations of science, education, technology and development.

Since a central concern is to bring into the same set of discussions the developments in science in education and the developments in science in society, it is important to make an initial comment about these two science milieux. Following Bernstein, it should be admitted that science in school or college is a fundamentally different activity and has a very different discourse from science in the world outside. The subject frames of school science are different, the pacing is determined by criteria completely different from the practice of science in the professions, government and industry. And yet in many curriculum statements, there is the suggestion that school science will offer insight into and practice in the scientific method.

There is a need accordingly to sort out the many different aspirations attached to the scientific enterprise in school, to distinguish these from the motives underlying the interventions of committed scientists in rural areas, and both from the practice of science and technology in the particular country. In any such analysis it becomes clear that a great deal is expected from formal and nonformal science. In school it is variously expected to communicate modern outlooks on the world, to help less developed countries to 'catch up', to allow pupils to participate in some aspects of scientific method, to give disadvantaged pupils a weapon with which they can offset social or caste bias. Similarly, in many different interventions in the countryside, the role of popular or people's science is multi-faceted, ranging from consciousness-raising, to promotion of appropriate technologies, to the dissemination of a scientific temper among the masses. Indeed a listing of the objectives culled from Indian intervention initiatives demonstrate the extraordinary mix of expectations associated with people's science:

- i to popularise scientific knowledge among the masses;
- ii to develop a scientific outlook among the masses;
- iii to challenge the forces of supernaturalism, obscurantism and superstition;
- iv to equip the poor with knowledge and skills to analyse and articulate their demands and rights in an effective manner;
- v to re-assess modern 'Western' science and technology which has grown mainly within the historical and economic context of colonialism;
- vi to re-evaluate non-Western or indigenous traditions in search of an alternative science and technology for our society;
- vii to develop appropriate technology and popularise it;
- viii to motivate professional scientists to work on problems that are relevant for the lives of the poor people;
- ix to involve science researchers, teachers, and students in mobilising the masses for structural change in society;
- x to build pressure on state structures to ensure that decisions are taken in a rational manner;
- xi to popularise self-reliance and the use of local resources in matters such as health, education, housing and industry;

xii to develop a critical awareness regarding the methods used in the present system of education, and to develop an alternative method of education, especially science education, that would be relevant to children's own lives.[1a]

When, in addition to these science-based strategies for rural areas, and the set of assumptions about the potential of school science, there is included the science and technology policies of the state more generally, it becomes clear that science is being drafted by many different interest groups to represent a particular approach to learning and action. But one of the problems appears to be that the essence of the scientific endeavour is not agreed upon; the common ground shared by the many groups using science as a banner does not appear very substantial. Thus, some agencies are associated with what looks like a rather straightforward message of 'science for all', popularising a basic scientific literacy across the total community of a country. Others are asking whose science is being popularised, and what is the impact of particular versions of Western science on local science and technology traditions. So far from school science and out of school science purveying basically the same method and approach, it is noticeable in certain settings that science-based interventions outside the school are in many cases anti-school. They perceive themselves as recuperating the many thousands whom school has failed or excluded; in many instances, the science message out of school is directed to village improvements in health, agriculture and self-reliance, whereas school science, for all its rhetoric of discovery methods, can be caricatured as ultimately concerned with certification and selection, and very little related to societal improvement.

The nature of science in industry and agriculture at the state level is also problematical in many industrialising countries. The relation

1a. Krishna Kumar, 'People's Science and Development Theory', ESPRA paper, New Delhi 1984, p. 3.

between the science system in the world of work and the operation of science in school and in various people's science movements is complex, and is made more so by the fact that the national science establishment is itself frequently involved in a set of complicated relationships with international sources of science and technology emanating from the industrialised countries. The set of interactions with which we are concerned in developing countries is ultimately not separable from the impact of science, technology and education developments in Northern industrialised countries. However, the main lines of debate in the seminar were concerned with the following relations:

- relations between the science education system and the national valuation of science;
- relations between the science of popular science movements and that purveyed in formal education
- interactions between transnational systems of scientific knowledge production and local systems

Cutting across the different levels of discourse, from the rural areas to the schools, and from the schools to forestry science, microelectronics and manpower planning was the notion of an alternative approach or an alternative paradigm with which to make sense of the contradictions in science and in science education. But the search for an alternative was not shared by all. Qualified support for science as the moderniser and transformer of society came from South East Asia, from the 'science city' of Singapore and from South Korea, which attributes so much of its contemporary scientific and technological capacity to the steadfast pursuit of science. Nevertheless, even in these settings where the reign of science and technology was generally unchallenged, there had been unconventional links between scientists and villages (Korea), and at least some exploration of the possibily complex consequences of overinvesting in science (Singapore). In India too, the meeting to some small extent reflected tensions within the wider community of scientists and social scientists about the nature of science in its relations to society; the tip of the iceberg of this extremely serious debate has been evident for two years in the public discussion for and against 'scientific temper'; but beneath this, there is a literature both wide and deep, going back to analyse Indian science and technology in the 18th century, re-examining the different faces of British colonialism in relation to science, re-interpreting Gandhi and the science question, and reviewing the many different shades of the people's science movement. There is also in India, as in any country, the science advisory personnel in government, reacting and formulating policy in relation to the politicians' decisions about technology imports, or protection of existing technologies. Here there is a good deal less latitude for manoeuvre than in the academic community and the private research centres. But yet, the whole sub-discipline of science and technology policy is founded on the belief that there are in many parts of government, decision-makers who at key moments lack the vital information on, for example, the dangers of eucalyptus, environmental degradation, or even the latest research insights on what can be expected of computers in schools. In the absence of such critical data - so the story goes - governments commit themselves often to expensive and unproven technologies, which are frequently questioned or abandoned later on (educational TV in the Ivory Coast is a case in point). We shall note later that the issue is not as simple as whether or not full research knowledge is available on the impact of the new technology. Nevertheless, it is all too common, as with new information technology, for Third World decision-makers to conceive of their countries as having no choice but to introduce a technology that is so markedly affecting the production and service sectors of the OECD countries.

There has been a great deal written on North-South relations in science and technology both before and after the UN Conference on Science and Technology for Development (UNCSTD). Some of this has indicted science and technology for becoming apparently 'instruments of global structures of inequity, exploitation and oppression', through the dissemination transnationally of inappropriate technologies, and the monopolisation of science R & D in military developments.[2] Other literature has focussed on the scope for the indigenisation of originally imported technologies, and on the development and adaptation of local technological traditions. Very recently for example, there has been a move away from the more extreme versions of technological dependency of the South on the North, and a renewed interest in the sources and extent of 'indigenous technological capability'.[3] However, what characterises a good deal of the literature that falls under the broad title of science-and-technology-for-development is that, first of all, it is more concerned with technology than with science; despite the coupling of science <u>and</u> technology, it is the latter that dominates discussion, whether in the accounts of technology transfer, technological change, technological dependency, indigenous (or endogenous) technological capacity, appropriate and inappropriate technologies or in the many recommendations about technology policy in the Third World. Second, whether the analysis of the impact of Western technology has been critical or whether it has been searching for local alternatives, there has been little attention paid to valuations of such technologies by the users and the receivers, or more broadly to the education systems that seek to institutionalise such values. To some extent this has been because the discourse on technology has been dominated by economists very properly anxious to sort out the costs and benefits of alternative technologies,

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2. See "The Perversion of Science and Technology: an Indictment", signed in Poona, India in July 1978, reproduced in Ward Morehouse, (Ed.) <u>Science, Technology and the Social Order</u> (New Jersey, 1979), pp. 413-417.)
3. M. Fransman and K. King, <u>Technological Capability in Developing Countries</u>, Macmillan , 1984.)

or of free market versus protectionist policies, or of investment strategies that can encourage the indigenisation and adaptation in the South of technological changes taking place in industrialised countries. But it has also been because till recently little attention has been given by education reseachers and sociologists to the impact of science and technology both in the formal schools and in nonformal education.

This meeting was an attempt to look at the value systems attached to science and technology, not just in general, but very specifically in relation to the exposure of the young to science in schools, and of adults to science movements in rural and urban areas. It brought together scholars concerned with the analysis of science in society, as well as those required to make scientific and technological decisions on behalf of their societies. To this extent it combined practitioners in science policy with people practising science-based innovation in school or society, and both of these with people critiquing philosophies of science and traditions of technology. A fruitful dialogue was possible because science education was conceived as something more than curriculum development in science subjects (valuable though that is), and because science policy at the level of the state was seen as something more complex than a strategy about what to promote and how to promote it.

The form of this paper will not follow the order of the meeting, but will explore two main avenues in respect of the analysis of science and technology in society. First, an attempt will be made to examine the extent to which the wider debates about science and society affect the major mechanism for exposing the young to science,- the schools and colleges. Second, for the adult population, some attention will be given to the assumptions that lie behind the myriad ventures that seek to offer 'science for the people'. In both these sectors there is, from the meeting, a larger concern about the science message mediated by scientists, science educators, textbooks, media, new technologies, and science experiments. There is also an awareness that the text of science and the codes of technology fall into a divided world. For the purposes of this discussion, the principal divisions are between the OECD industrialised countries and the less industrialised nations of the political 'South', and in the countries of the 'South', between the science and technology interests of the state and large firms in the modern sector on the one hand, and the promise of science for the poor, on the other.

The debates about science and school.

At one level there is no debate about science and school. In many, perhaps most, countries, science has replaced Greek and Latin in terms of subject status, and to that extent it acts as one of the prime filters to high paid jobs, whether in science fields or outside. Like the classics, science is widely assumed to have a value as an intellectual training, quite apart from the merits of the curriculum content. Beyond this, many would feel that science unlike the classics has a transformationist potential; to many developing countries, science and the scientific attitude seem partly to be what distinguishes the industrialised North from themselves. The scientific mentality is assumed to be diffused widely in the North, and its absence, particularly amongst rural populations, is felt somehow to be connected to poverty and backwardness. Science appears to have a further advantage over the classics: that it is not apparently so rooted in the cultures of the West as are Greek and Latin. So that although its arrival was often associated with the spread of western influence or empire, it has stayed on in the curriculum long after the departure of British constitutional history.

The above makes it clear that quite apart from the use of science subjects to mark academic success in school, science has been very firmly associated with modernisation in the minds of those framing the curricula of newly independent countries. Investment in science, as in education more generally, would give developing countries direct access to those technologies for which they have been so dependent on the West in the colonial period. Only a truncated version of science had been available under colonialism; now it could be turned into one of the main levers of national development. India's commitment to this faith in transformation by investment in science is widely evident in her post-Independence scientific manpower commissions, and is nowhere more elegantly summed up than in the Kothari Commission of 1966, which reported at the very height of the international consensus about the relation between high level manpower and economic development:

> While the development of physical resources is a means to an end, that of human resources is an end in itself; and without it, even the adequate development of physical resources is not possible...
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> For instance, there can be no hope of making the country self-sufficient in food unless the farmer himself is moved out of his age-long conservatism through a science-based education, becomes interested in experimentation, and is ready to adopt techniques that increase yields. The same is true of industry. The skilled manpower needed for the relevant research and its systematic application to agriculture, industry and other sectors of life can only come from a development of scientific and technological education....
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> Education as Instrument of Change. If this change on a grand scale is to be achieved without violent revolution...there is one and only one instrument that can be used: E D U C A T I O N.[4]

4. National Council of Educational Research and Training, Government of India, Education and National Development. Report of the Education Commission 1964-1966 (New Delhi, 1966), pp. 7-8. See further Ravi Chopra 'A select bibliography', ESPRA paper, New Delhi, 1984.

Another illustration of this faith in science potential was the building up often with substantial foreign aid of Science Education Centres, and Science Education Programmes. These developed in countries as different as Turkey, Lebanon, Sierra Leone, Brazil and the Philippines, to mention only a few. In a way, they were to some extent a riccochet into the developing countries of the sudden and dramatic funding for maths and science in the West that followed on the heels of Sputnik. But they had their own local momentum, and their preeminence served to underline the fact that what was expected from a science centre could not apparently be offered by English, History, Social Studies or other subjects.

Some part of the attraction of 1960s science to the developing countries was that there had just recently been a major paradigm shift in the West in the teaching of science. The new emphasis on discovery methods underlined the fact that students were not to be involved in merely memorising the laws and formulae as time worn as the Latin declensions; they would be operating as apprentice scientists, hypothesising, testing and confirming the results of their own experiments. The student-as-scientist philosphy, and its associated curricula, science kits and materials, appealed directly to many developing countries. Participation in what was thought loosely to be a universal method of the sciences fitted well into the aspirations to pursue active science with the overtones of building up a strong independent scientific community.

The epitome of this universality of scientific method, culture free, cutting across the old divisions between metropolis and colony was to be seen in the international agricultural research centres which were set up from 1960 onwards. They typified the view that pathbreaking scientific research could be carried out in developing countries, and that the results need know no frontiers. An early memorandum on the International Rice Research Institute in the

Philippines was characteristic of this model of scientific aspiration. The advantages of a single centre for rice research in Asia was that

a) international, or least multiple-country, cooperation in any field of science is broadly speaking, a good thing. It furnishes a basis for international friendships and understanding, and contributes toward a pattern of global living which is undoubtedly a desirable and necessary part of the future.

b) The basic problems concerning rice are universal problems, which can be properly attacked in one central laboratory which would then make the results available to all. Many of the really fundamental physiological, biochemical and genetic problems are essentially independent of geography and are certainly independent of political boundaries ; so that these problems could effectively and efficiently be attacked in one central institute.[5]

The message of the era, whether in schools, in agriculture, or in industry, was that the scientific methods, institutions and procedures were available, and they could be acquired and put to work for any people that was serious about development. South Korea was only one of the more dramatic examples of a nation's ability to buy into science and technology by its deliberate policy in the 1960s and early 1970s of building advanced science and technology capacity.[6] As soon as Singapore achieved internal self-government, it too declared for science, making it compulsory for primary and lower secondary schools in 1959, as part of a wider

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5. R.E. Chandler, An Adventure in Applied Science. A History of the International Rice Research Institute (IRRI, Los Banos, Philippines, 1982), p. 2-3.
6. For an account see Hyung-Sup Choi, 'The role of various stages of technology relevant to developing countries', Pacific Science Association, Bali, Indonesia 1977.

belief in building up the human capital of the nation.[7] In many countries science became the most powerful expression of the belief in the doctrine of human capital; a science or engineering graduate surely had the potential to assist the nation's economic development in a way that was qualitatively different from a history graduate, a lawyer or a sociologist. From this position, it is a short step to arguing that the country will need more science graduates than arts, and that the ratio should be moved, say, from 60:40 in favour of arts to 60:40 in favour of science. At the apex of the science training system, this kind of favouring of science over arts has not been uncommon in the last 20 years, whether in South Korea or in several parts of Africa. We shall return later to look at the manpower planning side of such calculations, but for the moment it should be noted as just one of a series of measures used to privilege science over arts.

Within a relatively few years of political independence in South and South East Asia, science, a commodity that had been in relatively short supply during the colonial period in the schools, universities and post-graduate schools, was everywhere available, symbolising the nationalist faith in rational change and development via the education system. By the early 1970s, the initial optimism of development economists and planners about rapid economic take-off had withered, and with the exception of the newly industrialising countries (NICs) such as Taiwan, Hong Kong, South Korea and Singapore, it looked as if the science-based investment in human capital was not going to transform societies overnight. We are not concerned here to rehearse the academic critique of human capital theory (which is widely available), but to note its very close connections with the privileging of science in school, university and society. It is however worth remarking that the last word has probably not been said yet on the human capital

7. Nicholas Tang, 'Investment and Overinvestment in Science Education', ESPRA, New Delhi 1984, pp. 1-2.

paradigm, and that few countries really sought to implement it with the commitment and authority of Singapore and South Korea, to mention two of the more obvious examples. Indeed, these and several other states continue to invest in different levels of scientifically and technically trained manpower with convictions unaltered by the debate of the last decade and more. Science manpower planning as part of economic planning is everywhere evident, for example in the rationale of the Nanyang Technological Institute in Singapore:

> The move is now towards restructuring the economy to high technology manufacturing and computerised services. This includes, among other measures, the expansion of engineering and technological facilities of educational training institutions at all levels to ensure an adequate supply of skilled workers. It is in this context that the Nanyang Technological Institute has been created to play a crucial role. [8]

It is also worth remarking that whatever the academic hesitations about the assumptions in the human capital theory, the rhetoric of investment in high level scientific and technical manpower is back on the agenda of many nations in the early 1980s. In the wake of the UNCSTD conference of 1979, several countries outside South East Asia are assuming that they gave insufficient attention to the science investment paradigm, and if they wish to join the 'science club', they had better invest more rather than less in science manpower.[9] Indeed there is now some evidence to suggest that donor agencies in the West, so far from despairing about scientific and technological investment strategies are returning more soberly to a version of the same human capital theory, in approaching the role of science and technology in relation to

8. 'Nanyang Technological Institute', Regional Institute of Higher Education and Development Bulletin, 1983, p. 10.
9. See further K. King, 'Some conceptual issues in scientific and technological manpower', ESPRA paper, New Delhi, 1984, p. 3.

higher education.[10] Possibly part of the same fascination with science potential is to be seen in the widespread interest in developing countries in participating in the current international evaluation of science achievement in schools orchestrated by the International Association for the Evaluation of Educational Achievement (IEA).[11]

Thus far, in examining the course of the debate, we have emphasised some of the rationale employed by countries continuing to back a version of the human capital approach through manipulation of science and technology in the formal education system. There is however a growing constituency concerned about the exposure to compulsory science, and about the increasing schemes for universalising schooling with a major science component. Some of this literature critical of science is not explicitly concerned with science as purveyed by schools and universities; in fact it is significant how little of the wider critique of science and technology in society has been applied to school and university roles in the reproduction of attitudes and competencies in the disciplines of science. We shall look now more closely at the implications of the critique of science for schools, and also at some of the conceptual and practical problems thrown up in the pursuit of 'discovery' science, compulsory science and compensatory science.

## The critique of science in school and society

We have remarked earlier on Bernstein's point that the activity and discourse called school science is very different indeed from

10. It is interesting to note that the former deputy minister of Science and Technology in South Korea has been acting as consultant to the World Bank in this very area of higher scientific investment. See Hyung-Ki Kim, 'Some basic elements in the development of scientific and technological infrastructure in developing countries', discussion draft, Washington, January 1983.
11. "The IEA second science study is being coordinated from the Australian Council for Educational Research, P.O. Box 210, Hawthorn, Victoria, Australia, and included some 40 participating countries as of September 1982.

science in society. Yet, the science teaching paradigm of the last two decades and more has been based on the opposite assumption: that the pupil through discovery methods 'could think about scientific things in the way that practising scientists do'.[12] In the British context, David Layton very appropriately makes the point that this approach makes some large and rather questionable assumptions about scientific activity, and particularly its apparent separation from society:

> ...only on the basis of the most superficial analysis of the nature of scientific activity, could it be said that such methods (discovery) enable children to think and work in ways characteristic of a successful practitioner of science....
> The view of science which informed the orginal Nuffield schools science project and the American..study projects, was 'science as search' and in so far as these courses were concerned to put children in the position of a scientific inquirer after new knowledge, the stereotype was that of the pure scientist, supremely oblivious to the applications and wider implications of his work. Science was studied as an end in itself.[13]

Apart from these fundamental questions about the nature of scientific activity, it also became rapidly obvious that discovery methods required a great deal of equipment if individual students were really to 'discover' things for themselves. So the technology of discovery science proved costly, and when discovery science was exported to many parts of the newly independent Third World in the1960s, it became apparent that there were high costs associated with the materials and kits required for discovery. The textbooks also insisted on discovery by offering no answers: 'Now, what is happening? Write down a hypothesis or possible explanation of what you see.' Paradoxically, this could make

12. Quoted from Nuffield Foundation's Science Teaching Project in David Layton, Science for the People (London,)1973, p. 175.
13. D. Layton, op.cit., pp. 175, 177.

the pupils more teacher-dependent in situations where insufficient materials or time meant that the teacher alone did the experiment, gave the notes, and where the textbook could not be used for revision.

Little work has been done on this, but it seems likely that discovery science with all the paraphernalia of kits, materials and educational technology was even more attractive in some ways to new nations who could interpret it as a chance to participate on an equal footing with the earlier industrialised countries. There was then and continues to be now a very lively concern about the creativity of the Third World scientist, and about the tendency for dominant theory and technology to derive from the North. The interest therefore in embracing discovery science is ultimately not dissociable from the wider concern, expressed so eloquently by J.P.S. Uberoi, about the role of Third World scholars in the generation of new theory, and the problem of deviating from the Western 'scientific ' paradigm:

> I am ....expected by my colleagues to confine myself within the duly certified professional sociological theories of modern times. In that even, the chief things to say are
> a)that such ruling theories, as I should call them, have all come out of the West; and
> b)that the West alone remains the sole authority in charge of them.
> By this definition, the non-Western world had lost the battle for theory, so to say, before it even began, and we can now only either do empirical work in India in the light of imported theory and method; or waste time and effort in complaining that borrowed concepts will not fit.
> ...
> At any rate... all other non-Western or non-modern ideas, theories and methods are definitely ruled out of court from the start as 'unscientific' systems of faith and belief rather than rational knowledge and as therefore unworthy of serious refutation, let alone any higher consideration. By the application of such means it is made to seem that there is only

> one kind of science, modern Western science, left to rule in the world today.... The rest is charmingly called 'ethnoscience' at best, and false superstition and darkest ignorance at worst.'[14]

Discovery science, itself a discovery of Western curriculum developers, is a small example of Uberoi's point. It became the new orthodoxy very rapidly in a number of developing countries - but by no means all. Just as the original ideas emerged from the West so did the growing critique of those assumptions. In this respect new science appears to have been somewhat different from new maths; the latter attracted eventually very powerful criticism in many developing countries, and was in some scrapped by presidential decree, as being allegedly unsuitable to developing countries. Whereas the criticisms and compromises with the new discovery science approach were certainly very evident in the countries of origin. In many quarters, however, the nature of the criticism was more concerned with practical issues (the cost of associated materials) and much less with the question of the kind of science that was on offer. From the point of view of this paper, it would seem that science educators have paid insufficient attention to questions about the nature and impact of the science being taught, and for this reason there is still too little interaction between the literature on science emanating from science studies centres and the pedagogical discourse about science education in schools. Some examples may be useful in pointing to issues that go beyond the narrower interpretations of science curriculum development, and which if given attention by curriculum specialists could influence the very way science is approached.

One potentially rich vein of research lies in the exploration of the intuitive belief systems that students bring to school. So far from the student as an apprentice, 'pure' scientist discovering for himself or herself new insights, the available data on students' intuitive understandings of phenomena opens up exciting visions of

14. J.P.S. Uberoi, Science and Culture (OUP, Delhi, 1978), pp.13-14.

cross cultural work across the North-South divide, and might even be taken to suggest that a form of 'ethnoscience' is not something that begins South of the Mediterranean, but is a common experience of students in school and university whether in Japan, India or Britain. In a recent review of literature on this 'other science', Rosalind Driver and Gaalen Erickson note the range of key concepts in physics where students have their own intuitive beliefs at odds with 'official' teaching in dynamics, gravity, heat, light, density, particulate theory, electricity, air pressure, to mention only a few. They comment on a major shift again in the school science paradigm:

> Until recently the major emphasis in the development of most school science curricula has been directed towards the structure of the knowledge to be taught. However, there is now a growing interest in the notion that students do possess 'invented ideas' based upon their interpretations of sensory impressions which influence the ways in which they respond to and understand this disciplinary knowledge as presented in the classroom. Evidence for the claim that students have intuitive ideas about natural phenomena abounds in the now extensive journal literature...
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> These student frameworks often result in conceptual confusion as they lead to different predictions and explanations from those frameworks sanctioned by school science.[15]

In India, Anita Rampal has come to a similar conclusion, realising that the implications for teaching science are very major. She argues that for pupils to shake the alternative frameworks they have built up over the years requires almost the kind of paradigm shift that from time to time has occurred in the history of science itself. The analogy with the history of science is not fanciful, for she discovered even in the most reputed public schools of New Delhi that at the end of secondary education 'pre-Newtonian beliefs

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15. R. Driver and G. Erickson, 'Theories-in-action: some theoretical and empirical issues in the study of students' conceptual frameworks in science', Studies in Science Education 10 (1983), pp. 38-39.

regarding force and motion seem to hold sway and that the quality and level of instruction appear to have no significant effect on the extent to which these beliefs are held.'[16]

There is another aspect of these larger questions about the kind of science paradigm to which students are exposed. For all the talk of discovery science and the encouragement of heuristic methods, there is considerable evidence that schools spend most of their time in science introducing students to the established knowledge and traditions of science rather than to any sense of debate or controversy. In this tradition which equally affects schools in the North and the South, discovery really means finding out the answers that everyone already knows. In the North this is done by "experimental" verification in laboratory work, in the South very often the codex of science is acquired directly from texts and exam guides without going through practicals and demonstrations. But there is probably more to this preference for proceeding directly to the codex than merely the expense of laboratory materials, oversize classes, and the relative inexperience of teachers in making lab work produce the 'right' answers. In several countries, for example, Singapore, and possibly other East and South East Asian nations, the tradition of deference by the disciple for the master runs through the social relations of schools, and is directly counter to a strong pupil-centred curriculum, even if discovery and inquiry methods are often in reality simply more labour-intensive forms of verification scinece.[17] In this sense, science education can become doubly authoritarian, both in its tradition and in its pedagogy conforming to Kuhn's description of it as 'a relatively dogmatic initiation into a pre-established problem-solving tradition that the student is neither invited nor equipped to evaluate.'[18]

16. Anita Rampal, 'How tenacious are intuitive beliefs in the process of learning science?', ESPRA paper, New Delhi 1984, p. 1.
17. Nicholas Tang, 'Investment and Overinvestment in science education', ESPRA paper, New Delhi 1984, p. 12.
18. Kuhn quoted in David Layton, op. cit., p. 219.

Science and Values in the North and the South

What tends to be missing throughout school and even college science is any sense of controversy either about the nature of science or its social implications. Clearly it should make a great deal of difference to the whole science teaching enterprise if there are questions about the very paradigm on which science is currently based. If, for example, the claims that modern science is value-free, objective, and epistemologically superior cannot be sustained satisfactorily in any examination of the role of science and technology in society, then something of this tension should express itself in the pedagogy.[18a] There are several dimensions of these conflicts between the nature of the scientific enterprise and the view of that enterprise as promoted in schools.

At one level there is simply the tension between the complex and often provisional nature of scientific knowledge in a particular field and the material offered in school texts. Arguably, in this respect science is no different from history or other subjects where school versions dramatically oversimplify human motivation or the role of the communities, classes and nations. Yet in science, there is a difference for it is assumed that the basic propositions of science in the lower secondary school are not provisional, or diluted versions of some later complexity. A rare illustration of this is provided by the remark of a Scottish science teacher recently that 'most of what is taught in school chemistry is white lies' when compared with the controversy about the most basic principles of chemical bonding that goes on in tertiary education.[19]

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18a. For an example of the conflict in 'scientific' values outside the schools, see Vandana Shiva, 'Government science and environmental action: the case of forestry in India', ESPRA paper, New Delhi 1984; the basic question about the validity of the text of science was posed also by Farzam Arbab in the ESPRA meeting.
19. Oral interview with principal teacher of chemistry, Edinburgh, February 1984.

These and other aspects of debate are generally excluded from the text of science as presented to schools, with the result that the other face of science is not on view at all. In this respect, as Paul Feyerabend argues, science education performs a dangerous disservice by objectifying and simplifying the history and method of the sciences:

> Now it is, of course, possible to simplify the medium in which a scientist works by simplifying its main actors. The history of science, after all, does not just consist of facts and conclusions drawn from facts. It also contains ideas, interpretations of facts, problems created by conflicting interpretations, mistakes and so on.... This being the case, the history of science will be as complex, chaotic, full of mistakes, and entertaining as are the minds of those who invented them. Conversely, a little brainwashing will go a long way in making the history of science duller, simpler, more uniform, more 'objective' and more easily accessible to treatment by strict and unchangeable rules.
>
> Scientific education as we know it today has precisely this aim. It simplifies 'science' by simplifying its participants.[20]

At another level, there is the potential for bringing out into the open the conflict to which we have already alluded between intuitive beliefs about science and the received wisdom of science (the latter itself affected by the qualifications of Feyerabend and others).

But at a much more general level, it should be possible for science educators and philosophers of science in developing countries to produce materials that reflect the distinction between the highly western origins of western science and technology on the one hand and the possibility of becoming scientifically developed without necessarily becoming like the West. This means becoming much more explicit about the way in which the sciences are 'parts of each culture's much wider system of experiencing nature and making sense of it', and are therefore intimately affected by the ideological

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20. P. Feyerabend, Against Method (London, 1978), p. 19.

role of science in that particular society.[21] If it is once admitted that the allegedly universal science subjects are in fact as peculiarly western as British constitutional history is British, then very major questions are raised for the science curriculum development communities in the Third World. In many, perhaps most cases, these communities have been willing parties in the import and repackaging of American and European approaches to the study of nature, in some countries using the very textbooks of Europe and America. There is no doubting the difficulty of developing in the face of such powerful opposition, fully developed sciences that will bear the marks of India or of China's rich and complex scientific past and present. One reason for the difficulty is presented by Sivin; American and European approaches have 'spread round the world' not because they provide 'the only conceivable basis for organising contemporary scientific work, but because the encounter between traditional and modern science in one society after another has been resolved by social change and political fiat, in view of which the comparative appropriateness of each system of science to the cultural environment is beside the point'.[22]

Despite this, it is probably now the case at least in India that research literature is available on the history, philosophy, sociology and psychology of Indian sciences to a degree that would allow the articulation and development of alternative science approaches. Work associated with Ashis Nandy, Dharampal, Rajni Kothari, Claude Alvares, to mention only a few names among many, could have a direct potential for translation into a very different set of science texts than the present.[23]

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21. Nathan Sivin (editor), Science and technology in East Asia (New York 1977) quoted in M.B. Anderson and P. Buck's very useful review 'Scientific development: the development of science, science and development, and the science of development', in Social Studies of Science (Sage, London 1980), Vol. 10, p. 228.
22. Sivin, op. cit. quoted in Anderson and Buck op. cit., p. 228.
23. See amongst much else, Dharampal, Indian science and technology in the eighteenth century (New Delhi 1971), and The beautiful tree (New Delhi 1983); Ashis Nandy, Alternative sciences (New Delhi 1980), and The intimate enemy (New Delhi 1983); Claude Alveres, Homo Faber: technology and culture in India, China and the West - 1500-1972 (New Delhi 1979)

But at the moment, it must be admitted that with exceptions to which we shall shortly turn, the science education texts give no flavour of any such alternatives, so rooted are they in the traditions and even the passing fashions of Europe and America.

The development of culture-dependent science frameworks in India or other countries implies a good deal more than what passes in the science education community for 'indigenisation'. This has often meant little more than Indianising the examples and illustrations in what remains an unchallenged set of assumptions about the nature of scientific knowledge and its current specialisations. For all the rhetoric about indigenisation in both national and regional science meetings, it is appropriate to question with Dean Nielsen whether 'after so many years of indigenous curriculum reform...there are any true examples of an indigenous science curriculum in South East Asian schools. Adopting an activity-oriented, discovery-based science is a significant reform, but in a sense it is simply exchanging an old imported model for a new one.'[24] Presumably one of the reasons for the lack of significant moves in developing alternative science frameworks in school texts in India is the view that there really is not much scope for 'localising' sciences as compared with social studies and social sciences. At Independence therefore in most ex-colonies it was history and geography that were indigenised, whilst the sciences received only minor adaptations. The widespread view that the sciences were culture free, and that Indian or African science was a contradiction in terms, underpinned these merely cosmetic changes in science education. More recently, however, it has been felt that such rethinking is essential not just for pedagogical reasons. But much more importantly, it can be suggested that such re-thinking is inseparable from any true popularisation of science, and may be an essential precondition for substantial innovation and creativity to take place in the Indian science community.

24. Dean Nielsen, 'Recent trends and issues in science education in Southern Asia', ESPRA paper, New Delhi 1984, p. 19.

Even satisfactory borrowing of new technologies must be predicated upon a widespread understanding of the history and values of some such local science framework, as Dharampal concludes:

> The problem of India today, as perhaps for many other lands which are still recovering from the effects of eighteenth and nineteenth century European dominance, is how to achieve and increase such innovation and creativity. Such innovation and creativity can however arise only from a widespread indigenous base. Such a base has yet to be identified...in countries like India. For that, knowledge and comprehension of how they (science and technology) functioned before the beginning of this dominance seems to be essential. Even for the purposeful adaptations from European (or for that matter Japanese, Chinese or any other) science and technology and the integration of these with the more indigenous concepts, knowledge and forms it is necessary that these countries achieve such knowledge and comprehension at the earliest.[25]

A last aspect that relates equally to science in education and science in society concerns what has been called loosely value-oriented science. The very term is a welcome admission that science cannot be excluded from the controversies and ideologies of society, as a monastic discipline pursuing its own routines in the purity of its withdrawal. The penetration of society by science and technology has been so comprehensive that the pursuit of disciplinary purity in the sciences is easily challenged. Nevertheless, as with the issue of indigenisation there is a great variety of positions taken in respect to science and values. There is, first of all, as with so much else the import to the Third World's science courses of a new concern in the West about relating science in some way to societal issues. Typically, science-and-society courses which discuss problems of pollution, energy, medicine etc are targeted at those pupils deemed less able to deal with the academic pursuit of chemistry, physics and maths. In this sense, science-and-society courses are used to make science more interesting to those who are classified as the future consumers

25. Dharampal, Indian Science and technology in the 18th and 19th century, op. cit., p. 54.

of technology. At their worst, they stress good shopping habits for the young adults; at best presumably they can constitute conscious scientific literacy, and an awareness of the inescapable controversies at the heart of developments in science and technology. The suggestion however that science-and-values may be useful for the consumers and not the producers of science and technology is a worrying conclusion from the way such courses fall into the hierarchy of scientific knowledge. In this connection it is interesting to note that in Singapore students who follow the less academic science subjects (such as Human and Social Biology, where it might be assumed science and values might be discussed) are termed 'sub-science' or 'arts' students.[26]

Apart from the strand of science-and-values that is associated with established trends in the West (see also UNESCO's current priority on science and the environment), there appears in a number of South East Asian nations to be a growing interest in a science education more related to ethical concerns, and in a greater social accountability for scientists and technologists.[27] At the moment it is doubtful if much of this has affected the schools, and unclear how it would affect the much more powerful value system that underpins the way sciences are taught. There is however becoming available material such as <u>The State of India's Environment: a Citizens' Report</u> which would allow science curriculum developers to see that the issue of science and of values is not 'how do we somewhat humanise the sciences', but 'how do we get popular discussion on the values that are part and parcel of the western science and technology package?' In its concluding 'Statement of Shared Concern', the report comments:

Our growing capabilities in science and technology have

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26. N. Tang, op. cit., p. 3.
27. Regional Centre for Education in Science and Mathematics, seminar on problems and issues in the teaching of primary and secondary science for development, <u>final report</u>, June 1983, quoted in D. Nielsen, op. cit., p. 6-7.

> helped us to acquire a technological literacy that allows us to converse with the rest of the world as equals and has rightly earned us international prestige amongst the community of nations. But science and technology cannot be allowed to impose their own value system on society. On the contrary, the use of science and technology in society has to be governed by a human, socially appropriate value system.[28]

One tentative outcome from the discussion about science education and values is that thus far it is very muted in the formal school and college science situation, but much more openly on the agenda of popular science movements, science journals and science fora. The majority of science teachers are illprepared, and probably disinclined to treat science as having a direct 'association with specific controversial issues which call into play children's discriminational and judgemental powers.'[29] We have however already implied that conflict in values lies full in the face of any attempt to build context-dependent science frameworks, since such frameworks will directly challenge the legacy of Western knowledge organisation. Hence value conflicts lie at the heart not only of the pedagogical organisation of science knowledge, but its application to society.

Possibly one reason why nonformal science education can reach more rapidly the issues relating to the roles of science in society is precisely because it has the freedom to redefine the organisation of scientific knowledge in ways that formal schools feel unable to contemplate. Thus, the Rural University in Colombia was able at the outset to critique existing knowledge frameworks in science in developing its own organisation of knowledge:

> The way a western university is organised in departments dealing with defined disciplines ia as much a reflection of a style of life, of a social ideology, and of historical realities of a people, as it is of a convenient division of knowledge to be grasped by individuals of different talents and inclinations. Therefore, when

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28. A Citizens' Report, (Centre for Science and Environment, New Delhi 1982), op.cit., p. 191.
29. D. Layton, op. cit., p. 184.

> a population establishes within itself an education system with such a structure, it is buying more than knowledge; it is making definite statements about its future social organisation.[30]

Becoming aware of the social consequences of how scientific knowledge is organised is an important first step in sorting out the values of science. And even if building a different and more appropriate framework for science may appear an impossibly long term - even utopian - goal, the very awareness of the need can lead to the teaching of science in new and unconventional ways. One detailed account of such a development is contained in the history of FUNDAEC, the rural 'university' in Colombia referred to above, and doubtless other detailed narrative can be found in India, such as the Hoshangabad Science Teaching Programme.[31]

It is possible that there is a great deal more alternative science being taught within the formal schools systems than we presently think; a good deal more school level research would need to be pursued to be certain. But, subject to such further research, it presently looks as if in a country like India the real questioning of science and technology values is going on in the informal or nonformal science movements. Tethered by examinations and reinforced by the status rankings for science subjects imported from the West, school and college science presents a very different face from the science activists in the popular movements. It is in the latter that there can be found the social and political controversies about science so necessary to any far-reaching indigenisation of science in developing countries:

> ...writers on the development of science and on science and development might consider drawing a lesson from the history of science in the West. Instead of worrying

30. Farzam Arbab, 'Engineers for Rural Well-being', ESPRA paper, New Delhi 1984, p. 8.
31. F. Arbab et al, Fundaec: an experience in rural development (1983, mimeo, 118 pages); for Kishore Bharati and the Hoshangabad Programme,see K. King, 'Science, Technology and Education Research' op. cit.

> about how to keep knowledge politically and ideologically chaste, they should be wondering how to make scientific theories and concepts into objects of social and political controversy in developing societies. Were that to happen, then science would be well on the way to escaping from the kind of sterile academicism which besets so much research in so much of the world. <u>More importantly, science might then take hold of the people of the Third World, and they might take hold of it</u>. 32

We shall return to the point later but at the moment it looks as if, in parallel with what has happened with much of the political activism in India taking place outside the established political party process, the rethinking of science and technology has begun outside the mainstream of institutions charged with the compulsory instruction in those subjects.

Before coming to look at the nature of this other science and technology being promoted in various forms of popular education, there is a strain of unconventional science being attempted within the formal school and college system. This unconventionality is less concerned with rethinking the nature of science, in the manner we have discussed above, and more alive to the consequences of compulsory science within national school systems. One consequence of compulsory science being introduced into the increasingly universal education systems of the Third World is that very large numbers of first generation learners experience science as the archetypically difficult subject, in which they most easily fail. There is little doubt that in many countries science now does play the role of selector of talent, to the extent that in some situations children identified as intelligent by their teachers are not allowed <u>not</u> to specialise in science. An illustration of a school system organised around this assumption is Singapore where streaming by ability in the New Education System is practised from the third year of schooling. One logical outcome of using science to

32. Emphasis added. M. Anderson and P. Buck, op. cit., p. 229.

distinguish success from failure is that it has been recently decided that for the lowest 40% of the ability range, it will no longer be necessary to pursue science in secondary school. It must be admitted however that what Singapore makes explicit is just as often the outcome in countries that maintain the rhetoric of equal access and equal opportunity, and even, in the case of India, make special educational provision for the 'weaker classes' of society. The net result of the schooling-for-all, or science-for-all slogans is that most do not achieve meaningful schooling or an insight into science. Whatever may be said about science popularisation for society, the schools' interpretation of science keeps it strictly within an elite stratum of knowledge, hedged about by complex language and procedures.

Centres such as the Homi Bhabha Centre for Science Education (HBCSE) have shown convincingly in the face of massive drop-out and school failure by the weaker sections of society that what has traditionally been considered as science failure has more often than not been failure to deal with the complex language in which science is presented. The simplification of the surrounding language has allowed access to the science, and the natural curiosity of students about natural phenomena has not been stifled by use of artificial linguistic barriers. The same was found to be true of the symbolic language of formulae, graphs, equations and drawings in which so much science and maths is couched; students were failing in the languages in which the sciences were mediated, almost before they had any insight into the content of science.[33]

Perhaps partly derived from this concern to allow students direct access to question-raising about natural phenomena has been the interest in India, and in other countries in providing schools

33. V.G. Kulkarni, 'Universalisation of education. Problems and remedial measures', ESPRA paper, New Delhi 1984, passim.

with science kits. These deserve research study in their own right for they can be taken as a microcosm of the larger attitudes to scientific experience in schools. The more complex electronic project labs commercially available in the West offer to children high quality packaged kits with manuals describing 200 or 300 attractive ploys or 'experiments'. The very titles indicate that the barrier between play and study is under attack: sonic zoo and sound factory; electronic elephant; buglar alarm; electronic roulette etc. One of the commonest of these 200 in 1 science fairs turns out to be made by the US multinational, Radio Shack, a division of Tandy Corporation. At the very opposite end of the kit spectrum are those associated with HBCSE, which at a twentieth of the price stress local materials, open-endedness, and are as unpackaged as a kit can be:

> The basic philosphy is to demonstrate that educationally relevant and intellectually satisfying activities can be conducted using material readily available in one's neighbourhood. However, such a philosophy does not work in a vacuum. Making available a seed around which growth is possible can achieve very good results. The teachers in this project have multiplied the contents of the kit several fold.[34]

But with kits, as with textbooks, and science laboratories, it would seem that they can both reflect the existing science paradigms, or be used to raise questions about their operations. Often it seems that the educational technology side of kits is stressed to the exclusion of any exploration of the code or the assumptions about science that are implicit in the kit. For example, the science kit in the West suggests that some form of science can leave the lab and be taken home. Most commonly in developing countries, the kit is not so much a supplement but the only source of certain materials in the poorer schools. The very process of deciding what are the minimum essential learning needs for tens of

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34. Kulkarni, op. cit., p. 23. See also K. King, 'Science, technology and education research in India', August 1982; and Nielsen, op. cit., pp. 7-8.

thousands of schools offers a fascinating insight into lowest common denominator science priorities. The kit therefore encapsulates an integrated set of assumptions about what must be experienced through doing, and what must simply be learnt. It would be surprising in this situation if there were not a series of compromises between what can satisfactorily be kitted, and what cannot, even though the latter may be regarded as essential.[35]

Similar questions could be raised about the role of labs. What really determines what can be learnt without any practical, what is best demonstrated by the teacher to the whole class, and what is preferable for the students to do for themselves, either individually or in groups? Often it appears that such questions are decided by such practical matters as availability of time, imminence of exams, teacher competence, presence of technician support, or the choice of particular 'discovery' textbooks rather than what it is about a particular part of the codex of science that needs visualisation or experience. It is also obvious that there are intriguing differences within physics, chemistry and biology in the extent and type of lab work, use of controlled experiment etc. Some of this appears to have as much to do with the very different traditions in the different sciences as it has to do with pedagogical theory about practicals or discovery learning. Equally, the highly theoretical approach to physics and chemistry in the People's Republic of China, and to some extent in South Korea and Singapore may, we have suggested, point to a good deal more than the lack of labs, or exam orientation; it may suggest that sciences are built upon a somewhat different organisation of knowledge than that in Europe and America. Such issues would be worth exploring in a little more detail as Korea and China are currently being drawn, partly through aid moneys, into patterns of science exposure more common to western schools

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35. For some of the most innovative thinking in relation to school science kits , see Hari Parameswaran's science kits, and his paper 'Creativity and children', ESPRA, New Delhi 1984.

and universities. Such research would be important, not only because of what has been said about alternative science frameworks, but also because at $ 350,000 US a time, fitting out a single lower secondary school's science laboratories is not cheap.[36]

Much of the concern with labs and kits has been derived from desires to compensate science in the Third World for the absence of the richer science environment in the West both in school and outside. Also within the developing world, kits and local forms of discovery science have been utilised to compensate disadvantaged groups and put them on a more equal footing in competing with traditional learners. The most successful interventions of this sort have however not so much been questioning the existing school science paradigm, as preparing weaker sections of society to succeed where failure has been traditional. Challenging conventional expectations for lower caste children possibly made it essential, in the first place, to demonstrate that such children could succeed <u>in the same race</u> as middle class students, more especially when certification is only available from following identical courses to those in the ordinary state schools.[37] To some extent, therefore, the political necessity for lower caste children to succeed in the same contest as other children means that the most exciting initiatives in school science alter the pedagogy more than the paradigm, whereas in out of school science movements both the pedagogy and paradigm are being challenged.

One final example may be useful for exploring somewhat further the North-South interplay of values in science which bears very directly on the two aspects of compensation with which developing countries are concerned: catching up with the North, and allowing

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36. This is the current price in Singapore; see N. Tang, op. cit., p. 14. For some of the controversy about learning and science labs, see research reported in Nielsen, op. cit., pp. 20-21.
37. Kulkarni, op. cit., p. 27.

the rural and poorer urban areas to catch up with elite schools in the cities. We have stressed that in the absence of explicit alternative frameworks for science in developing societies, the tendency when presented with major innovations from the North is to seek to absorb them, as part of the evidence of 'becoming modern'. By far the most visible of the science-related innovations of the last several years is the move to introduce computers into schools, at both primary and secondary level. The claims made by those promoting these go far beyond the use of the computer as a tool to aid certain kinds of calculation or reinforce learning in the manner of the older computer-assisted-instruction. It is suggested that the interactive learning now possible can make for qualitatively different cognitive experiences in school and home. Advocates of the experience have particularly emphasised the impact on mathematics and on science, and so closely have OECD countries regarded these investments in schools as impinging on national capacity in new information technology that few governments have hesitated to subsidise national suppliers to aim at the school market. At American universities, an even fiercer battle is being fought out by the main microcomputer manufacturers to supply, free or at highly subsidised rates, their products to professors and students. Already four universities have declared that students must bring computers with them as a precondition of entry, and Carnegie-Mellon confidently expects to have 7,500 personal computers by 1986, outnumbering students and faculty.[38] Fundamental changes in teaching, research and in the organisation of learning are claimed to be imminent, finally transforming the labour-intensity of education in ways analogous to office automation, 'paperless' banking, and computer-aided design and manufacturing.

When clearly so much is expected from large scale investments in computers in schools in the West, tremendous pressure is generated

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38. 'Computer firms battle for hearts and minds', New Scientist, February 9, 1984, p. 23.

in many Third World countries to follow suit. When the rhetoric is all about the educational counterpart of the new information technology revolution, it must sound to many planners and politicians that the technology gap (and allegedly the educational achievement gap) is going to be widened dramatically.[39] Even more troubling, this new information technology in schools is claimed to be fundamentally different from the older world of audio-visual extras, which were always sold as aids or supplements to learning. The new technology is projected as a new way of learning, but like many technologies it already has a context and code built around it, and these reflect the present state of this technology in the West. Any Third World country buying into new information technology for schools has to be aware of this wider packaging, the main elements of which are:

- the introduction of computers in schools is inseparable from the massive marketing of personal computers into homes;

- computers are multipurpose, and can be used for video games as readily as for more educational uses. The availability of the leisure software has sweetened the introduction of the technology in home and school, and has allowed nonformal learning at home and from peers to support the formal use in schools;

- the availability of tapping into phone and radio networks, TV networks for information and for leisure software by home and school owners of micros, dramatically extends the functions of the technology, as does the ease of machinery for copying, replaying and swapping software with other users;

- the modelling and graphics options of the new technology are all based on the universality of colour TV, or colour monitors in the West, and these in turn linked in almost a quarter of all homes in the U.K. to video recorders.

- the availability of up to 200 computer magazines for amateurs to professionals, and a mass of do-it-yourself manuals and books in the chain stores of the West.

39. K. King, 'The pursuit of science manpower in the 1980s: conceptual problems', ESPRA paper.

- some hardware (e.g. Zx Spectrum) and the software are available at prices which even schoolchildren can afford if they have saved a little money. Swapping and 'pirating' mean that whole software programmes change hands amongst school children for as little as forty pence (a dollar).

This is the wider 'text' of computers in schools, and it implies that a Third World country may not get the same result from concentrating on the school end alone, since the commercial and home applications may be missing. It also suggests that in the absence of cheap, reliable and widespread phone, radio and TV coverage, the multiplier effects of the new technology will be missing. Furthermore the cheapest hardware is a week's wage in the West and the software perhaps two hours of adult work, compared to several months or several days respectively in many developing countries. All of which means that a handful of microcomputers in schools may have a good deal less impact than their counterparts in the West. Compared to the relatively large numbers of microcomputers in secondary schools in the West, and the possibilities of doing class teaching with a bank of 10 to 15 micros each offering different programmes, it is much more likely that schools acquiring these in developing countries will have sometimes only one or two, and consequently will tend to treat them with caution.

Nothing that is said here or in other fora is likely to halt the march of new information technology into the schools of Thailand, Singapore, Korea and India; indeed in several of these, computers are part of the school furniture, and in others major pilot experiments have been agreed. But, as in the West, decisions are being taken on the introduction of the new technology with little or no research evidence. Countries that are attracted by the potential of science and technology to transform society will tend to see this particular technology as offering an option that cannot be refused. The more difficult issue for social scientists, and educators concerned with science and technology, is to reach some judgement about the impact of this technology. Again, as with kits, labs etc, it is not simply a question of affordability, urban-rural contrasts in availability, indigenous technological capacity versus imports, important though all of these are; from the perspective of this paper, it is also a question of whether the knowledge production associated with new information technology fits into, or can be adapted to the knowledge and technology traditions of another society. In many societies, this must seem an academic question, but in countries like India where there is a highly developed awareness of technology traditions, and where contradictions in tradition are obvious in architecture, medicine, forestry and other disciplines, an analysis could be developed in the area of new information technology that drew upon these alternative frameworks in science and technology.[40] Although there are still very few analyses of the impact of NIT in Third World schools, there has already been an outpouring of literature on the phenomenon in the West, to a point where one of the most recent reviews of the subject (David Hawkridge, New Information Technology in Education, London, 1983) has no less than twelve pages of relevant bibliography. But as we have implied, the task for developing country scholars concerned with the technology involves sorting out the way NIT is situated in the wider Western communication systems from the meanings and relevance it could have in urban and rural India. If such a critique is to have any influence on policy, it needs to be carried out before major decisions are taken to commit resources to the new technologies. This then implies that Third World scholars need the opportunity to review emerging technology in the industrial heartlands of the North, if a view about their suitability is to be developed before the almost inevitable pressures for adoption arise from politicians and commercial interests. In such an endeavour, there will be some

40. Examples of the search for such frameworks are to be seen for several disciplinary areas in the Patriotic and People-oriented Science and Technology Bulletin, Madras, vols. 1-3.

merit in examining traditions in the North itself which are critical of the social and political implications of new information technology. The problem however for linkages between alternative traditions in the North and South is that the available literature is much harder to locate, and tends to be submerged in the advocacy and promotional writing on new information technology.[41]

Science for the People, People's Science, Science Popularisation

Throughout this paper we have from time to time alluded to the existence of groupings concerned with science which operate outside the formal classrooms and labs on which we have been focusing, and we have implied that such groups may well be able to act in ways that are not so directly affected by the patterns and paradigms that so dominate the regular education systems. Alternative frameworks and conceptualisations of science may be more likely to arise in such nonformal settings than in the certified science of school, college and government research laboratory. When science moves from the world of specialised disciplines, journals, and mission oriented research on space satellites, new technologies etc to the world of 'science for villages', people's science movements, or 'engineers for rural well-being', what happens to the context of science? Earlier it was suggested that under the popular science banner a considerable variety of different pressure groups find a home, and it may be timely since the union of 'science' and 'people' is taking so many forms - even linguistically - that some clarification of the partnership be undertaken.

First it may be useful to distinguish some aspects of popular science in the Third World from the anti-establishment science that has become commonplace in the West. The latter usefully consists in setting scientific expertise against the establishment's scientific

41. See however 'Information technology: a socialist analysis' in Science for People, No. 53, 1982; and The Techno-Peasant Survival Manual: the book that demystifies the technology of the 80's, (Bantam, New York 1980).

expertise, whether in the sphere of pollution, radiation, food, health or environmental issues. Typically the science-based pressure group (such as Green Peace, Friends of the Earth etc) contests the scientifically attested safety of or need for a nuclear power station, hydro scheme, drug or dumping arrangement; science is thus set against science, and in the process it becomes clear that scientific judgements are controversial. Unlike the mainstream science of school, much of the activity involving pressure groups opposing big business or government makes it clear that science is intimately affected by politics, that science expertise can be arrayed on diametrically opposed political issues. It is interesting also to note that the very subjects that receive so little attention in school science (pollution, environmental degradation, agricultural chemistry, drugs and health) are at the heart of science controversies after school. The courses relating to such subjects are only offered to weaker students, and are seen as inferior to the allegedly purer disciplines of physics and chemistry. Of course, contestations between government science and environmental science lobbies occur also in developing countries; indeed, a classic example is that over eucalyptus in India waged between the eucalyptus lobby (with support from pulpwood users, Forestry Department, government research and even external aid) and small groups of researchers concerned with the scientific study of indigenous systems of farm forestry.[42] One feature, however, that distinguishes groups in the North is that while some run across party lines, a number are explicitly marxist or socialist, and this in turn defines relationships with the constituency they seek to involve and work for. Thus the British Society for Social Responsibility in Science (BSSRS) naturally defines 'people' as the labour movement:

BSSRS is a group of scientific and technical workers in

42. See V. Shiva, 'Government science and environmental action', op. cit., also V. Shiva, 'The ecology of eucalyptus', ESPRA paper; see also, Centre for Science and Environment: The State of India's Environment, op. cit., ch. 3, 'forests'.

> industry, hospitals, education and research establishments. We believe that science is not neutral and cannot be separated from politics. It both reflects and helps determine the value of society. Hence to change the social role of science it is necessary to change society. We are committed to fighting for the use of science and technology by and for the benefit of working people, to demonstrating the political content of science and technology and to furthering the links between scientific and technical workers and the rest of the labour movement. 43

We shall note by contrast that in India in particular the various expressions of people's science tend to be part of a wider non party political process in the rural areas.

Before turning to examine grassroots popular science movements, it may also be worth noting the popular science aspect of science centres and science museums. These certainly see themselves as very different from the mainstream science curriculum of schools, but whether they are really working from an alternative conception of science and technology is debatable. What is clear is that museums and science centres are going through a paradigm shift, away from the passive display of objects and inventions in glass cases to an active involvement in the discovery (or more accurately rediscovery) of scientific principles. In that process, whether in the Exploratorium of San Francisco, the Exploratory in Bristol, or in the Community Science Centre in Ahmedabad, young people and adults are urged creatively to question their sense perceptions, to get behind illusions to the principles that make things work. Although museum planners see such activities as being popular science, there is still some sense in which community science centres face school-like problems. For one thing, their hands-on approach to perception, reflection , mechanics, hydraulics etc is the same principle at work as the schools desired with their discovery learning, but if the schools found that practical discovery learning

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43. Science for People is the BSSRS journal; Science for the People is the American counterpart. Radical Science Journal is a British journal critiquing science, technology and medicine from a radical political, usually marxist, perspective.

interfered with the demands of theory and of exams, science centres may find the opposite, that the practical gadgetry for demonstrating the principles become ends in themselves. In addition, permanent user-friendly practicals are expensive to create and maintain, and it is no accident that such science centres are much more common-place in America than in Europe, and in Europe than in the Third World. Britain, for example, only has one such in operation at the Human Biology Gallery at the Natural History Museum, and another starting in Bristol, and India only one in Ahmedabad.

But apart from the dilemma of cost involved in this form of popular science, it is necessary to examine the agenda and 'curriculum' of such displays. It is not of course possible to lay out objects either in the old curriculum of glass cases, or in the new inter-active mode without their being a judgement offered about the view of science portrayed. Arguably, it would seem that the new mode will market science more effectively, but it is possible that the message will be the same at the end of the day. Thus a commentary on the Bristol Exploratory:

> It is sad that the educational system does not generate excitement and understanding; and science museums, wonderful though they can be, are passive and often fail to convey the excitement of science. And because they do not understand it, many people reject and fear science. This is why we are setting up Britain's first science centre. [44]

This message is likely to be that behind the sometimes deceptive exterior, science in all its order and reason awaits discovery. As with some school science kits, the tendency will be to package discovery, particularly in those areas most amenable to uncovering the "mysteries of science." For example in an encouragment to the public to produce a successful exhibit for the Exploratory, the advertisement reads:

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44. 'The Bristol Exploratory - a feeling for science', New Scientist, November 17, 1983, p. 484;see also Jayashree Mehta, 'What does a science centre do for urban population?', ESPRA paper, New Delhi 1984.

> All we ask is that your exhibit would invite the visitor to 'interact' with it: it should attract attention but should not reveal all its secrets until the visitor has pressed the appropriate buttons, pulled the necessary levers, or whatever. [45]

This doesn't mean that science centres cannot play a popularising role, but it is one that needs close analysis. For instance, they could very usefully deal with the area of intuitive belief systems of children (and adults), which we noted in discussing formal science education. Counter-intuitive exhibits and demonstrations could fit very easily into science centres, and could be a dramatic supplement to the work of the schools. But for developing countries, it would at least be worth noting that the large multipurpose science centre is very much (like other superstores) a creation of a particular communications society, where there is no difficulty in transporting busloads of children to a single site. By contrast in China, it has been commonplace for children to disperse into 'many and varied forms of scientific and technological summer and winter camps' where children can participate in observing earth science, astronomy, biology, navigation, solar energy, earthquake zones etc.[46]

The main thrust of popular science activities in developing countries seems to be less involved with either the highly academic science pressure group of the West, or the work of nonformal science centres. Rather it consists of various modes of participation between science activists and villagers. The range of these interactions are many, and they span the relatively official campaigns of science popularisation (e.g. in Ethiopia), the direct encouragement of each village or larger community to have an urban scientist attached as adviser and trouble-shooter (Korea), or the work of hundreds of individual catalysts working with villagers in India. At the most official

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45. 'The Bristol Exploratory', op. cit., p. 489, emphasis added.
46. Sun Ruohan, 'Extra-curricular science education system for middle and primary school students in China', Regional meeting on 'Science for All', Bangkok, September 20-26, 1983.

level, there is often a sponsored dialogue between villagers and parts of the scientific establishment. The tendency of these official encounters is frankly modernising, or that the artisan skills of the villagers can be improved by injections of scientific expertise. In Korea's scheme for sister relationships between one community and one scientist, the ingredients of success have been: political committment to the scheme at the highest level; the incentive structure for professors altered to reflect rewards for village-oriented success; and a tendency to attach professors to their own home communities. This institutionalisation of university links to the community appears to have had advantages in both directions:

> the people at the grass roots level learned much from having presented their problems to those from the universities, while the university people in their turn obtained invaluable insights into the lessons on how education should prepare people to solve practical problems.[47]

In Korea, the scientists-to-villages scheme is not an isolated incident but part of a massive, multi-faceted, multi-media attempt to incorporate the rural areas into a science-based society dedicated to relatively high technology, high value-added production, whether in city or countryside. As a small country, with extraordinary levels of political and social commitment to the task of transformation, the issue of alternative frameworks in science and technology, or the role of indigenous knowledge organisation are seen as diversions from the goal of rapid change, and the spread of a modern science and technology climate. With such objectives, the usual tensions associated with appropriate technology versus sophisticated can be resolved in favour of what is <u>needed</u> for competitive production. With rural incomes now virtually identical to urban, the Korean miracle has apparently created a united science and technology climate across the country, and can claim no longer to have the separation of science in cities and poverty in villages that characterises so

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47. Hyung Sup Choi, 'Role of the Saemaul Technical Service Corps', ESPRA, New Delhi 1984, pp. 13-14.

so much of the developing world. There is very little literature available at the moment which examines the social impact of this extremely dramatic penetration of the western science and technology paradigm, and on closer inspection it may appear that in the processes of indigenisation and adaptation of technology, there have been important effects coming from older traditions and valuations of science and technology. At this point, however, Korea presents a face that has little in common with the situation in South Asia. The science popularisation is presented as involving all in a unified cause of rapid modernisation, and to this extent it really appears that Korea is a perfect exemplar of the UNESCO slogan 'science for all'. The thrust of the campaigns is uni-directional, and there seems, perhaps understandably, to be little questioning about the science and technology paradigm which Korea has manipulated so signally to her advantage.

This modernising strain is evident in other countries, and manifests itself in slogans like 'scientific temper', in science policy resolutions, and in many other programmes and projects, but it is immediately obvious from the context of such statements that science has not got the field to itself. Over against scientific temper are ranged the forces of tradition, superstition, communalism and parochialism according to the many debates on this theme. In one of the more recent of these set pieces in India, a group of distinguished scientists have each spoken out on the theme of 'scientific temper or bondage of traditions', and contrasted the rationality of the scientific method with the tendency to be governed by unreason and obscurantism. The tone of these arguments makes it clear that the scientific temper is conceived of as a political philosophy, whose absence accounts for the ills of the state. By contrast, the Green Revolution is an excellent example of the scientific method in action; science,knowing no frontiers and respecting no particularistic criteria, proceeds to benefit the nation:

> Notice that the method used in the above situation (green revolution) concerns itself only with the conditions of seeds, soil, water and so on, and not with whether the seed belongs to a Hindu or a Muslim, or whether the field is Indian or Burmese. These are irrelevant to the problem; what is relevant is the actual seed and the soil, the quality and amount of water and physical environment, and not the nationality, religion or political policy of the individual or the country.
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> ...Geographic parameters such as soil hardness, rocky terrain, or weather conditions are considered but not the religious beliefs of the farmer or his family life - these make no difference to the problem on hand or its solution. 48

This classic statement is reminiscent of the International Rice Research Institute with its belief in research knowing no frontiers, but it typifies the view of science as an entire system and method, itself uncontaminated by social and political forces, but hopefully becoming the ruling principle. At the moment the ills derive allegedly from the separation of science from the state, but if the scientific method can overtake the state itself, all will apparently be well:

> We have mentioned earlier that the method of science be made use of in all aspects of human endeavour from ethics to politics and economics. Much of the impediments in societal or national progress stem from a refusal to adopt scientific temper or from confining the scientific method to problems of technology or health alone and not to all problems associated with human progress. 49

The perception of science not only as a method, but as a systematic and culture-free approach to politics, contradicts much that has been said above about the origins and paradigms of western science and technology. Still in one form or other, the gospel of science as the moderniser and shaker of tradition remains strongly held, and is the activating principle at work in many of the science popularisation movements. Several of these assume that what villagers require is a large transfusion of scientific temper, to alter their fatalism, their prejudices, and their traditional belief systems.

48. D. Balasubramaniam, 'A living philosphy to fight obscurantism' in Scientific Temper of Bondage of Traditions, Yojana, New Delhi, vol. 27, August 15, 1983, p. 29.
49. D. Balasubramaniam, op. cit.

In this kind of people's science project, therefore, it is the scientist who is carrying science to the people, in the hope that the new gospel will not only have cognitive consequences, but more importantly alter the attitudes and values of villagers. In this respect, science though contrasted with the evils of religion and dogma is recommended for its impact on values. So far there has been little detailed research on the nature of the science and the associated values carried to the villages by many of these dedicated scientists. However, Krishna Kumar has drawn some important threads linking the assumptions of the scientific temper activists with those common to western analysts of underdeveloped societies in the immediate post-independence period:

> Many writings of the period used an evolutionary paradigm ...to explain a 'missing factor' in the societies of the poor countries. The missing factor was identified by many commentators in terms of cultural or behavioural deficiencies; as a lack of certain traits that were regarded as necessary for rapid economic growth and social change. These were traits such as achievement motivation, initiative, independent will, and affective neutrality. The socio-political programme of science educators resembles the early developmentalists in as much as it links certain observed traits in the behaviour of poor people with their political subservience. The diagnosis offered is similar, only the symptoms are named differently. 50

There are several variations of this approach. Some involve bringing to bear on artisan technologies in the village the insights of the national system of scientific laboratories, as for example in the current scheme for 'village artisans and science' of India's Council of Scientific and Industrial Research.[51] Others may have less institutional backing, but they conceive of nonformal science education being an engine for rural development. One interesting aspect of these programmes is their strong emphasis on science,

50. Krishna Kumar, 'Science Education and Development', Centre for the study of developing societies, mimeo, New Delhi 1982, p. 14.
51. 'CSIR S and T field station at Bankura project: village artisans and science', National Institute of Science, Technology and Development Studies, CSIR, New Delhi 1983; or R. Gupta, R. Matthai eds, <u>The Rural University: The Jawaja Letters</u>, Indian Institute of Management, Ahmedabad 1981.

despite the evidence that much of what is on offer is technology. It seems almost as if science is used as a symbol, for the 'curriculum' of science education in some programmes is so practical that it appears to be at the very end of the spectrum from school science. Much more work needs to be done on the nature of this 'science' for villages, but a not untypical account comes from the Vidnyan Ashram, near Pune:

> The methods and approaches of science cannot be inculcated except by practice, which in turn is possible if one sees it as effective. The methods we try to inculcate relate to 1. discerning patterns. 2. cause and effect relationships; 3. quantification and measurement. 4. experimentation 5. recording and exchange of information. These should be imparted by games, exercises and use. The most creative mind will not be effective unless it has information to work on. As the time is very short, it is possible to absorb only a limited stock of information and we would like to give only that which is relevant to local life. Instead of trying to write down a syllabus for this, we decided to start tackling the local problems and give only information which relates to them. Over a period certain concepts and fact get repeated and will be absorbed. 52

These encounters between the formally-trained scientist and artisans, or other villagers, have been little documented, but there are important questions to be asked about what happens to the scientist's science when it is deployed in a village setting, or to the science of the National Metallurgical Laboratory when it confronts the improvement of rural artefacts. It is possible that the dialogue could be a very fruitful illustration of interaction between two very distinct traditions, - the world of the craft worker and that of the government scientist. One of the few detailed examples of how this interaction between different paradigms cannot remain a merely technical question of urban science improving rural technology is contained in a qualitative account of the Jawaja weavers and leather workers who became involved in the 'rural university' outreach organised by the late Ravi Matthai:

> For anyone thinking that improving the design of the weavers and leather workers, and arranging small bank

52. S.S. Kalbag, 'Science education and rural development', ESPRA paper, New Delhi 1984, p. 1.

> loans is something that can be rapidly initiated, and can allow the project team to move on elsewhere, these (Jawaja) letters are compulsory reading. There turn out to be almost endless ripples of obligation and accountability that spread out from the few initialchanges in design and in tanning technology; there is also a constant awareness of the trade-offs between fixing things and increased dependency. 53

Not the least significant of these various initiatives taking scientists to villages is so obvious it is seldom remarked on: the presence of highly trained post graduate personnel in a village is so unusual, it may be expected to have an effect almost independent of the science and technology message that is being imparted. Unlike traditional agricultural extension systems - where the village workers are at the bottom of the agricultural research hierarchy, and are the last link in a very attenuated chain, the scientist settling in a village for a long time could have a powerful impact as a 'science missionary'. In the rather different context of Colombia, when FUNDAEC was rethinking the whole traditional chain of knowledge generation from research centre to the peasant, it had also become clear that by privileging the village-end of this process, one would be challenging the view of the village as the passive consumer of predigested technology packages:

> While this institution (FUNDAEC) would not be involved in activities such as the development of new varieties, its tasks would be far more complex than that of an extension system including feed-back mechanisms, and it would need to have much more scientific capacity than has traditionally been allotted to institutions working at the grass roots level. 54

Science activism and grassroots movements

Conceptually distinct from science as modernisation, but sometimes appearing in the same movement is a form of science-as-liberation. In many cases, however, this liberatory science is on the agenda

53. K. King, 'Science, technology and education research in India' op. cit., p. 15.
54. F. Arbab et al., 'Fundaec: an experience in rural development', mimeo 1983, p. 45.

of what have come to be called non-party political formations, that is, in the myriad of small local grassroots initiatives working with marginal groups. Such grassroots movements are independent of the traditional party processes, and are also separate from the more establishment non-governmental organisations. Their work is almost exclusively with the large sections of the population who have profited little from three decades of independence and 'development'. In recent months, the crucial political and social character of these small groups has been analysed by Harsh Sethi, D.L. Sheth, Rajni Kothari and several others, and there is the beginnings of a small literature laying out the nature of this 'new politics' in the rural areas.[55]

By no means all of these grassroots movements would identify themselves with some form of science-for-liberation, but there are a number of characteristics of their approach to knowledge and its utilisation which strike chords with some of the alternative paradigms to which we have alluded. It is in fact premature to be more than tentative about the meaning of science in the titles of some of these movements, or to assess the use of scientific expertise by them, for the very good reason that few descriptions exist except in outline form. Although it will be important to know more about these science and action agendas, it is well to heed the warning of Sheth about the use of evaluation research and its assumptions in documenting such initiatives. 'Scientific' evaluation criteria could easily 'delegitimise' the popular science purposes of these movements:

> This is done in the name of 'evaluation' studies of these new experiments and organisations, mounted by established social scientists, both foreign and local. In this, the work and role of

55. See Harsh Sethi and Smitu Kothari (eds) The Non-Party Political Process: Uncertain Alternatives, UNRISD/LOKAYAN, New Delhi 1983, mimeo; also D.L. Sheth, 'Grass-roots initiatives in India', Economic and Political Weekly, vol. 19, no. 6, February 11, 1984; and Rajni Kothari, 'The non-party political process', Economic and Political Weekly, vol. 19, no. 5, February 4, 1984.

> grass-roots movements is assessed not in terms intrinsic to their existence, but against the establishment criteria of what development is and what it is not. 56

Even though data is scanty, there are a few pointers to the nature of this science activism. First, in India, the nature of these grass-roots organisations has been much affected by the movement of middle class, educated youth to settle and work with the marginal groups, whether tribals, agricultural labourers, backward castes etc. To this extent, there is therefore a similarity to the various modernising science groups, since both contain as catalysts highly educated, committed urban dwellers, often with a science background. The difference with the grassroots groups is that on the whole they are searching for an alternative model of development to that which has allowed the tens of millions of rural dwellers to remain in poverty, whereas the modernising groups may see the problem as partly an absence of that very development mentality. It is possible however that there may be a continuing tension between the science paradigm in which the catalysts or change agents were educated and the demands that knowledge empower the poor. It implies a complete change in the aspect of science from its association with selection, elite formation, and traditional R & D models, to one where it is expected to be raising the awareness of the poor, and demonstrating alternative methods for maintaining health, technology and the environment. In this, it may often in Sethi's works be converting 'an ostensibly "neutral technical profession and task" into a "political" one'[57]

A second aspect of this science activism is its tendency to pay attention to indigenous technical knowledge over against the scientific development schemes which have in many instances threatened the balance and stability of older ecological systems.

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56. Sheth, op. cit., p. 259.
57. Harsh Sethi, 'Redefinitions: groups in a new politics of transformation', in Sethi and Kothari, op. cit., p. 102. Reprinted in Economic and Political Weekly, vol. 19, no. 7, February 18, 1984.

In many other countries modern science (whether in forestry, agriculture or fisheries) has paid much more attention to the commercially exploitable, export crop than to the ordinary food crops and local uses of timber. Consequently, there is considerable scope for research on subsystems that mainstream science has neglected, and in pursuit of these, there is advantage in making the research itself participatory; so that the very people whose habitat is threatened by commercial interests or monocrop farming can become conscious and articulate about their local resources. Examples of such scientific awareness creation can be noticed in the Kerala People's Science Movement (KSSP) in relation to the Silent Valley Scheme, or the Chipko Movement in the Himalayan forests. While one of the most useful statements about the participatory methodology applied to science and technology is Shiva and Bandyopadhya's, 'Participatory research and technology assessment by the people'. To some extent, it may appear that such participatory science research is defensive and reactive to crises created from time to time by the intervention of commercial interests or 'development' plans. It might be argued that an alternative science and development strategy may be difficult to construct around the irregular incursion from such quarters, and even more, if alternative frameworks are to take local knowledge as their starting point, the specificity and uneven distribution of such knowledge may be as marked in its own way as the specialisation and elite character of the dominant science paradigm. Conscious perhaps of this dilemma, science activists see the participatory mode as a two way process - in which neglected knowledge begins to feed into the national awareness, and in which the role and character of the dominant science system is translated into the people's local perceptions. However, one of the most critical aspects of this translation is that the broker between the two systems is the science activist or catalyst. In a small local initiative an enormous burden and responsibility must fall on this translator as Shiva and Bandyopadhya admit:

> In this sense, elite knowledge must be recognised as a source of power and exploitation - and countering this knowledge by knowledge generated through participatory research becomes a very essential and potent aspect of people's struggles. If this process is to materialise, the macro-researchers have to identify themselves with the people and play the double role of subsuming people's knowledge into professional terminology and re-translating macro-knowledge into popular language. 58

One further point should be made about this brokerage role. It would be important to know more about the scientific perspective which the broker brings to the study of local knowledge systems, and in turn to the selection and translation from the dominant knowledge modes. Is the expertise with which they counter the intrusive technologies and with which they analyse the local technical knowledge based on that same Western scientific method? Once having accepted that the western science and technology system is not value free, generalisable and epistemologically superior, is there still a legacy of procedures and approaches which science activists derive from western science? The question is important for it relates to one that Farzam Arbab has raised: whether the essential text of western science is good, and only the claims made of it and its applications by particular interest groups appear to make it bad, or whether the text of science itself is at fault.[59] Perhaps only more detailed studies of science-in-action in these campaigns and in these interactions can answer these questions. But in rejecting the reigning economic development model, with its exploitation of resources needed for popular livelihood, is there a role for scientific expertise to counter the case made by the 'developers'? If this is so, is there then a set of tools that science (or social science)makes available, whether in participatory research or in the older R, D and D models? Is there a minimum western science package or 'kit' which can be utilised for expertise,

58. Shiva and Bandyopadhya, op. cit., p. 123. Emphasis added.
59. F. Arbab, comment during ESPRA seminar, New Delhi.

regardless of political perspective?[60]

Although it is plain that the reinterpretation of indigenous knowledge in science, agriculture, education, and medicine can provide a starting point for the alternative approaches to science which we have discussed, it is important to acknowledge that in some parts of the Third World researchers feel this local option does not exist, as an aid to developing different frameworks. According to Farzam Arbab for example, there is in Colombia no viable alternative that can be nurtured in the field of agriculture. Consequently there is a pointlessness about those 'who reject modern technology and try to seek solutions in the traditions of each rural region. In general, they tend to romanticise the past and try fruitlessly to recuperate it.'[61] From a rather different perspective it is worth noting that the largest of India's popular science movements, the KSSP, which has fought a number of developmental projects, is anxious not to be identified with a zero-change approach to the environment: 'Great care had to be taken to dispel any possible impression that the stand amounted to an anti-development view. It was with this in mind that feasible alternatives which would confer greater benefits to the people in terms of employment and income were worked out and propagated.'[62]

In several quarters it can be seen that there is an anxiety to distinguish the reinterpretation of local knowledge systems from an anti-science kind of revivalism. Popular science movements have therefore to tread a very narrow path, critiquing the excesses of modern science and technology, equally with contesting the view that the modern is alien. Among the several conflicting versions of 'science popularisation', the middle way may frequently have the

60. Dinesh Mohan has commented on the value of the set of science tools, even for those countering the incursions of western science, ESPRA seminar, New Delhi; for a further example of countering the expertise of the dominant development models, see J. Bandyopadhya and V. Shiva, 'Planning for Underdevelopment: the case of Doon Valley', Economic and Political Weekly, vol. 19, no. 4, January 28,1984.
61. Arbab et al, op. cit., p. 41.
62. Science for Social Revolution, KSSP, Trivandrum 1980, pp. 22-23.

least appeal politically or emotionally. Thus, science popularisation that simply wishes to spread broadcast the values of western science and technology is undoubtedly easy to understand, and, like a literacy campaign, can be mounted readily, given political commitment. Similarly, a campaign against the infiltration of western influence in science and technology can easily gain political support. Compared with these, a science popularisation that reinterprets and rediscovers the changing local traditions while sorting and selecting from other technology traditions is conceptually difficult to grasp. In addition it has to forge a methodology for this double sorting that goes beyond the rhetoric of participation, and identify areas of analysis far beyond the domains of the still uncolonised Masai herdsmen, the tribal peoples and the forestdweller.[63]

One of the most difficult tasks in this search for a legitimate or appropriate popular science is changing the discourse away from saying what it is not, towards descriptions of what it is. Currently there are scarcely any detailed descriptions of what is involved in bringing an appropriate science and technology to light. There is, however, no shortage of general statements and declarations in favour of 'Another Development' or of the need for 'endogenous development', but these need to be translated into detailed drawings, if they are to move from the agendas of international meetings to reflect the problematic search for alternative frameworks.[64]

One of the few such detailed drawings is contained in the ten years' search by FUNDAEC, the 'rural university' in Colombia, for an appropriate model for the development of human resources and of

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63. The complexity of finding a legitimate people's science and technology is well illustrated in a recent dialogue between the Patriotic and People-oriented Science and Technology (PPST) in Madras and local writers: see Lokayan Bulletin No. 8, pp. 3-10...some members of the PPST suggested that the writers should help the intellectuals by identifying practices of traditional science and technology in obscure corners of the country' (emphasis added.)

64. One of the better known attempts to stake out the high ground for alternatives is Another Development: Approaches and Strategies, Dag Hammarskjold, Uppsala 1977.

technology. The account of the development of theory and the challenge of practice, the successes, the cul-de-sacs, the failures are all essential if there is going to be built up in different settings a new paradigm or an alternative framework. Part of the singularity of FUNDAEC was its insistence on developing human resources and technology in tandem, not assuming that either had to remain simple because it currently was, not that either had to become sophisticated through the conventional structures for acquiring academic status and academic complexity. Educational and technological appropriateness had to be understood in terms of a dynamic relationship to each other, rather than to any traditional stages of development:

> The appropriateness of technology is a changing quality that would have to be understood within the broader context of the process of development with the human being as its primary concern. The needs, the aspirations, resources, and capabilities of a population at a given moment are clearly important factors in determining the worth of a technology, but they have to be examined in light of their contributions to the expansion of the scientific and technological capacities of the population. A simple technology may be quite inappropriate if it leads to stagnation, and a complex one may be appropriate or not, depending on the accompanying educational process and whether it leads to real understanding of and complete control over the technology. The rural university was thus beginning to understand appropriateness more and more in the context of the systematic learning process within the population about its own path of development, in terms of which it was already formulating its concepts of education. 65

In the light of this insistence upon a coordinated developmemt of human resources and of science and technology, it is interesting to note that similar kinds of action groups see themselves concerned with 'popular education' in Latin America and 'popular science' in India. It is almost as if education and science are seen as platforms

65. F. Arbab et al, Fundaec: an experience in rural development, op. cit., p. 42.

for the new politics of these many groupings, but they are not the old conceptions of science, technology and education. The reformulated relations between science, technology, education and politics are embryonic, but the example of FUNDAEC and of several other action experiments suggests that a new social relations of science is feasible. There does now exist a solid body of work on alternative technologies; there is also considerable work now available on alternative, participatory research techniques, and these will prove very relevant for further detailed case study work on popular education and science movements. It should therefore be possible to move from the present situation of an array of scattered movements to a new conceptualisation.[66]

But the task of privileging this alternative image should not be underestimated. Despite all the criticism the dominant science and technology paradigm is still in the saddle. The international agricultural research centres continue to exemplify the approved system for developing and distributing new agricultural information. International science congresses continue to operate on the assumption that there has been no basic criticism of the mode of westerm science and technology, or that criticism from the Third World can be met by encouraging the export of some portion of the same research technology to the developing world. Over against all that has been said in this paper, national governments proceed with plans for investment in the same paradigm, whether in new information technology, elite science schools, science cities or other manifestations of the belief that science can develop or transform society. This is of course not just a science phenomenon, but part of a wider problem of transnational knowledge production and power, and their impact on developing countries. The empowering of alternatives in the Third World is therefore inseparable from the analysis of the 'world system' to which Arbab referred at the beginning of this paper, nor

66. See also UNRISD, Popular Participation Programme, 'Social Movements and the State', Geneva, June 1983.

can it fail to take account of the vitality of the dominant paradigm and its set of supporting structures which Weiler has mapped out:

> Much of this (Third World) criticism is, of course, directed against trends towards the monopolisation of knowledge production, especially in social research, by a single paradigm or 'symbolic universe' - a monopoly which reflects the overpowering role of the North American research establishment and the paradigmatic traditions which...have come to dominate that establishment over the past fifty years....Beneath this overt criticism of a reigning paradigm, however, lies the recognition of a much more fundamental dilemma: the recognition that what is really at issue is not 'just' the world of knowledge production and research, but a much more intricate web of relationships in which the production of knowledge is one of several interlocking elements for the consolidation and legitimation of the existing institutional order at the international and transnational level. The transnational system of knowledge production is inextricably linked to a transnational system of power, in which publishing interests, research funding, consulting firms, testing services, professional associations and development assistance agencies all form part of a powerful - if less than perfectly co-ordinated - centre. On the other side is the research community in a weak and, above all, fragmented periphery which finds itself not only dependent upon many of the centre's resources, but also locked into an intellectual agenda which is jointly sanctioned by the dependent state and the economic and political forces in the centre of the international system.... 67

One conclusion from situating the search for alternatives within an awareness of these wider international constraints is to make sure that the analysis of a new politics of science, technology, and education does not get located solely in the periphery of the periphery, - seen as an appropriate defence strategy for the poorest of the world's poor, but not being particularly relevant to mainstream national and international knowledge systems. Researching alternatives must also relate directly to the role of science and technology in

67. H. Weiler, 'Knowledge and legitimation: the national and international politics of educational research', Comparative and International Education Society meeting, Atlanta, March 18, 1983, p. 21.

the so-called modern sector, or organised sector of the economy. Hence there is a need in parallel with the development of theory among popular movements to investigate alternative conceptions and meanings for scientific and technological manpower. Here too, despite all the criticism of traditional paradigms in manpower planning, with their emphasis on middle and higher level technical and vocational training, these human capital models continue to dominate, and are being fast updated and adapted.[68]

By contrast, alternative models for examing the role of scientific and technological manpower are scarcely available, and where they do exist, they have seldom the visibility or impact of manpower analysis coming from the traditional sources of expertise in the ILO, or the World Bank. A sustained critique of the conventional wisdom on skills development cannot be found, but must at the best be pieced together from commentaries scattered here and there in the 'grey' literature.[69]

What are the implications of this situation for the many scattered researchers working on the new politics of science, technology, skill, and education? Is there a way of achieving greater salience for the approaches with which this paper has been involved? Currently, such alternatives little affect national and international

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68. See for example the papers in the South Asia Regional Conference on Skilled Manpower Development, (Government of Sri Lanka and World Bank), Sri Lanka, January 1984, mimeo.

69. See for example journal of Foundation for Education and Production, Gaborone, Botswana; A.T. Ariyaratne,'Promotion of skills development in the community', South Asia Regional Conference, op. cit.; Dinesh Mohan, 'Retooling', Seminar,(New Delhi) January 1983, and 'Research in Developing countries: innovation and comparative advantage', ESPRA paper, New Délhi 1984; K. King, 'Conceptual issues in the analysis of scientific and technological manpower', ESPRA, New Delhi. Also A. Benachenhou, 'Technological Development and educational planning: reflections on a debate', International Institute for Educational Planning, 1984, mimeo; also A.K. Dasgupta, 'Economic growth, manpower, education and science policy: effective interrelationships', ESPRA paper, New Delhi 1984.

planners in science and technology, manpower economists or even the hundreds of thousands of science educators. Are there ways that the body of alternative thinking and acting on these issues can be brought in from the periphery and can begin to affect science and technology policy at the central level? The following are a few suggestions that may point in the direction of a research and dissemination strategy for these alternatives:

- Much more case study material needs to be made available documenting the insights and strategies associated with these new approaches to science, technology and education. While resistance and suspicion of conventional evaluation techniques is commonplace amongst groups attempting new initiatives, appropriate forms of participatory evaluation are now available, and in the absence of published accounts of alternative theory and practice, the field is left to the traditionally dominant paradigm.
- Building theory from the many micro-initiatives in Asia, Africa and Latin America is a priority task, not principally to understand new forms of participation and politicisation amongst the poor, but to see one of the major sources of criticism of the current 'development' theories.
- To counter the universal 'culture-free' science of the schools, universities, and science congresses, many more accounts of culture-dependent science and technology are needed, - fully developed sciences yet ones that will bear the marks of India or China's rich and complex scientific past and present.
- Although very few funding agencies are prepared to support research and dissemination of alternative knowledge frameworks, those that are inclined (UNRISD, IDRC, SAREC, UNU, IIEP, CLACSO, for example) should be requested to make possible a great deal more South-South learning, as well as exposure to alternative foci on science and technology in the North. In addition, given the impact of Northern scientific and technological research on the South, it will be important to encourage <u>Southern</u> research on the latest technological changes in the North.

- One of the most essential routes to strengthening alternative paradigms is to produce materials suitable for teaching, in graduate schools of education, development studies, and science and technology policy. New materials are also urgently required for the school system itself.
- At the moment, the conventional paradigms predominate in all the key planning sections of ministries of Education, Manpower, Science and Technology, Rural Development, Agriculture and Industry. Ways should perhaps be explored of exposing policy research personnel in these ministries to alternative conceptions of skill, science and technology, agricultural extension etc through workshops and high level seminars. In the absence of some such initiative, policy makers continue only to have access to workshops on project evaluation and monitoring, manpower analysis, technology assessment or on investment in science and technology education, most of which will take no account of the concerns expressed in these pages.

The search for an integrated alternative vision will proceed, and will be conducted not only in the defence of the very few unexploited peripheries (such as the Amazonian rain forest), but more centrally in the ordinary village schools and training centres, amongst science teachers, and in science and technology policy centres. But the search cannot preclude attention to those parts of the Third World pursuing the popularisation of the traditional western science paradigm, whether in South Korea, Singapore or elsewhere. Countries that have aimed at transformation by investment in science must be part of the agenda of research, and not only the myriad of scattered initiatives that have some sense, that a "post-modern science" may be emerging from the discrediting of the current paradigm.[70]

It is too early to say what a new linking of science and values (a 'technoethic' in Nandy's words) will look like in different countries

70. Ashis Nandy, comments at ESPRA seminar, New Delhi 1984.

but it will need to incorporate not only the traditional and changing technologies of the countryside but the current industrial and evolving information technologies of the city. One version of that vision is J.P.S. Uberoi from his book Science and Culture; who sees that the alternative framework is fundamentally about the reorganisation of knowledge production:

> On the scientific side, the new way of life and thought will require us to restructure the project, the curriculum and the hierarchy of the special sciences, theoretical and experimental, so as to discover and affirm the higher unity of the subject and the object, the man and the system. The new classification will abjure within every special science the distantiation of outer nature from the inner man, the participant from the observer, as a principle of knowledge. For example, within the new physics, a search for the elementary structures of mind as well as matter should replace the search for the elementary particles of matter as its object. This will in its turn point some new relations between physics and psychology and between physics and ethics as well as between physics and mathematics. The new social sciences will learn to live and let live within the new vision of the whole. Similarly, medical science will have to add inherently the concept of sanity (subjective) to its concept of health (objective), defining human life as health plus sanity inseparably from the start.
>
> ......
>
> I am persuaded that so long as the problem of the alternative is seen in India and elsewhere in purely practical extrinsic terms, whether political, social or economic, modern Western science itself will remain a stranger and liable to exploit us for its own ends. Its so called diffusion, implantation or assimilation in the non-Western world will very properly remain a failure or turn into something worse. On the other hand, if the intrinsic intellectual problem of the positivist theory and praxis of science and its claims come to be appreciated by us, leading to a dialogue with native theory and

praxis, whether classical or vernacular, then modern Western science will find itself reconstituted into something new in the process. Let us see whether the king who makes all the laws of modernity cannot be brought himself within the semiological law, i.e. in relation to the project, the curriculum and the method of science. 71

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71. J.P.S. Uberoi, Science and Culture, op. cit.,pp. 85-86. See also, A. Nandy, 'Traditions of Technology' in Ward Morehouse, (ed.), Science, technology and the social order, op. cit., pp. 371-385; also Sunil Sahasrabuddhey, 'Gandhi and the science question', ESPRA, New Delhi 1984.

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EDUCATION, SCIENCE POLICY, RESEARCH & ACTION

AN INTERNATIONAL REVIEW MEETING, NEW DELHI

10-13, JANUARY, 1984

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